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(54) Optical disk device and replacement processing method

(57) In this invention, in an optical disk (1) on which data is to be recorded in units of one ECC block constructed by 16 sectors, dummy data is recorded at the manufacturing time or at the initial time such as the application starting time, then the dummy data is reproduced to determine a sector with primary defect, the address of the sector which is determined to have the primary defect is recorded on the optical disk (1), and at the time of data recording, data recording is effected in units of one ECC block while skipping over the sector with the primary defect. The determining condition for the primary defect is a case where address data of the address field cannot be reproduced (first condition), or where the number of rows in which the number of error bytes is four or more is five or more (second condition). Further, in the optical disk (1) on which data is to be recorded in units of one ECC block, data is recorded at the time of data recording other than the initial time, then the data is reproduced to determine an ECC block having a sector with secondary defect, and data of the ECC block which is determined to have the sector with secondary defect is recorded in an ECC block which is separately prepared. The determining condition for the secondary defect is a case where address data of the address field cannot be reproduced (first condition), where the number of rows in which the number of error bytes is four or more is five or more (second condition), where the number of rows in which the number of error bytes is four or more is not larger than five, the number of rows in which the number of error bytes is four or more is three or more and the number of rows in which the number of error bytes in one block area is four or more is ten or more (third condition), or where at least two sector areas in which the number of rows in which the number of error bytes is four or more is five or less and the number of rows in which the number of error bytes is four or more is three or more are present in one block area (fourth condition).

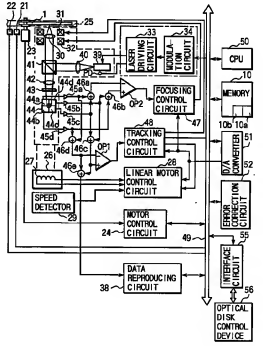

FIG. 1

EP 0 798 714 A2

Description

This invention relates to a recording and reproducing optical disk device for recording data on an optical disk and reproducing data recorded on the optical disk, a recording optical disk device exclusively used for recording data on an optical disk, a reproducing optical disk device exclusively used for reproducing data recorded on the optical disk, and a replacement processing method for effecting the replacement process for a defect area or defect areas in the optical disk device.

Conventionally, an optical disk device for recording data on an optical disk having recording tracks or reproducing data recorded on the optical disk by use of laser light emitted from a semiconductor laser oscillator mounted on an optical head has been put into practical use.

With the above optical disk device, data is recorded on the optical disk in units of one ECC block constructed by a plurality of sectors.

In this case, an optical disk device is proposed in which whether or not data is correctly recorded in units of one sector is determined at the manufacturing time or at the initial time such as the application starting time, and if a sector with defect is detected by the above determination process, an ECC block including the sector is determined as a defective block and is treated as an unusable block.

Therefore, when successive data items such as speeches or moving pictures are recorded and if an ECC block (defective block) which is unusable is present, a slip replacement process for recording data on a next ECC block after skipping over the above ECC block is effected. That is, the data recording operation is interrupted for a period of time corresponding to one ECC block.

Thus, the optical disk device has a defect that the reproducing operation is interrupted for a period of time corresponding to one ECC block, for example, when successive data items such as speeches or moving pictures are reproduced.

Further, there is proposed a process for determining whether or not data has been correctly recorded for each sector at the recording time after the initial time, dealing with a defective sector as an unusable sector if the defective sector is detected by the above determining process and recording data by use of a sector prepared in a different area for replacement.

In this case, if data recorded on the sector of the different area is not simultaneously reproduced when one ECC block is reproduced, reproduction of the whole ECC block cannot be effected. That is, originally, the sectors of one ECC block can be successively reproduced, but in this case, it becomes necessary to reproduce the sector for replacement in the course of reproduction of the ECC block and then successively reproduce the sectors of the original ECC block. Therefore, the reproduction speed is lowered.

An object of this invention is to provide an optical disk device capable of recording data so as to permit data to be continuously reproduced when successive data items such as speeches or moving pictures are reproduced even if a defect replacing process is effected at the manufacturing time or at the initial time such as the application starting time.

Another object of this invention is to provide an optical disk device capable of continuously reproducing data when successive data items such as speeches or moving pictures are reproduced even if a defect replacing process is effected at the recording time after the initial time.

Still another object of this invention is to provide an optical disk device capable of continuously reproducing data when successive data items such as speeches or moving pictures are reproduced even if a defect replacing process is effected at the manufacturing time or at the initial time such as the application starting time.

Further, another object of this invention is to provide an optical disk device capable of suppressing a lowering in the reproduction speed even if a defect replacing process is effected at the recording time after the initial time.

According to one aspect of this invention, there is provided a replacement processing method for an optical disk which has tracks arranged in a concentric or spiral form for data recording and in which a format having a plurality of successive sector areas each having a preset track length and including an address field for recording address data indicating the position on the track and a recording field for recording a recording data is defined, the recording data recording is effected in units of one block area containing a group of a preset number of sector areas among the plurality of sector areas and including an error correction data recording area in which error correction data items used for reproducing data recorded in the preset number of sector areas are collectively recorded for the group of the preset number of sector areas, and each of the sector areas has a plural-byte configuration, comprising the steps of:

recording the recording data and error correction data into the recording field of each of the sector areas on the entire surface of the optical disk at the manufacturing time or at the initial time such as the application starting time;

reproducing the recorded the recording data and error correction data and the address data in units of one sector area;

determining occurrence of a sector area with defect in a case where address data in the address field cannot be reproduced at the time of reproduction or the number of error bytes exceeds a specified value;

recording address data of the sector area which is determined to be defective;

successively recording the recording data and error

correction data into a plurality of successive block areas on the optical disk; and

skipping over a sector area with defect in units of one sector area based on the recorded address data and recording the recording data and error correction data into a next sector area in a case where the recording data and error correction data is sequentially recorded into the plurality of sector areas in each of the block areas.

This invention can be more fully understood from the following detailed description when taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a block diagram showing the schematic construction of an optical disk device for explaining one embodiment of this invention;
FIG. 2 is a plan view showing the schematic structure of an optical disk shown in FIG. 1;
FIG. 3 is a diagram showing the schematic construction of the optical disk shown in FIG. 1;
FIG. 4 is a diagram for explaining the rotation speed of the optical disk shown in FIG. 1 for each zone and the number of sectors in one track;
FIGS. 5 and 6 are diagrams each showing the construction of an ECC block of the optical disk shown in FIG. 1;
FIG. 7 is a diagram showing the construction of each sector of the ECC block of FIG. 6;
FIG. 8 is a view for illustrating preformat data in a header portion of the optical disk of FIG. 2;
FIG. 9 is a diagram showing the sector format of the ECC block of FIG. 6;
FIG. 10 is a diagram showing a recording example in a defect management area recorded in the rewritable zone of the optical disk of FIG. 2;
FIG. 11 is a view for illustrating detectors for detecting the presence or absence of the optical disk of FIG. 1 and the open or closed state of a cartridge;
FIG. 12 is a flowchart for illustrating an initial defect list forming process;
FIGS. 13 and 14 are diagrams showing the relation between physical sector numbers and logical sector numbers, for illustrating the slip replacement process in units of one sector;
FIG. 15 is a diagram for illustrating the slip replacement process effected in units of one sector when successive data items such as moving pictures are recorded on a plurality of ECC blocks;
FIG. 16 is a diagram for illustrating the linear replacement process in units of one ECC block;
FIG. 17 is a diagram for illustrating the reproducing order of the ECC blocks in the linear replacement process in units of one ECC block;
FIG. 18 is a diagram showing the relation between physical sector numbers and logical sector numbers in an ECC block for replacement when the linear replacement process in units of one ECC block is effected; and
FIGS. 19 and 20 are flowcharts for illustrating the process effected when data is recorded in a preset ECC block.

There will now be described an embodiment of this invention with reference to the accompanying drawings.

FIG. 1 shows an optical disk device used as an information recording device. The optical disk device is used to record data (information) or reproduce recorded data by applying converged light to an optical disk (DVD-RAM) 1 used as a recording medium.

For example, the disk 1 is a phase changing type rewritable disk which is constructed by forming a metal coating layer of tellurium or bismuth in a doughnut form on the surface of a base plate which is formed of glass or plastics in a circular form, in which data is recorded or recorded data is reproduced by using both of concentric or spiral grooves and lands and on which address data items are recorded at preset intervals by use of recording marks in the mastering step.

As shown in FIGS. 2 and 3, the optical disk 1 has a lead-in area 2, data area 3 and lead-out area 4.

The lead-in area 2 has an embossed data zone 5 constructed by a plurality of tracks and a rewritable data zone 6 constructed by a plurality of tracks. In the embossed data zone 5, a reference signal and control data are recorded at the manufacturing time. The rewritable data zone 6 is constructed by a guard track zone, disk test zone, drive test zone, disk identification data zone, and a replacement management zone 6a used as a replacement management area.

The data area 3 is constructed by a plurality of zones, for example, 24 zones 3a, • • •, 3x which are formed of a plurality of tracks arranged in a radial direction.

The lead-out area 4 is a rewritable data zone which is constructed by a plurality of tracks like the rewritable data zone 6 and in which the same data as the recorded content of the data zone 6 can be recorded.

As shown in FIG. 3, the optical disk 1 has the embossed data zone 5 and rewritable data zone 6 of the lead-in area 2, the zones 3a, • • •, 3x of the data area 3 and the data zone of the lead-out area 4 sequentially arranged in this order from the innermost portion, the same clock signal is used for the above zones, and the rotation speed of the optical disk 1 and the number of sectors of one track are different in the respective zones.

In the zones 3a, • • •, 3x of the data area 3, the rotation speed becomes lower and the number of sectors of one track becomes larger as the zone lies at a farther distance from the innermost portion of the optical disk 1.

The relation between speed data as the rotation speed and the number of sectors for the above zones 3a, • • •, 3x, 4, 5, 6 is recorded on a table 10a of a memory 10 as shown in FIG. 4.

As shown in FIGS. 2 and 3, in the tracks of the zones 3a, • • •, 3x of the data area 3, data items are

previously recorded in the ECC (error correction code) block data unit (for example, in the unit of 38688 bytes) which is treated as the data recording unit.

The ECC block is constructed by 16 sectors in which 2k-byte data is recorded, and as shown in FIG. 5, each of sector ID (identification data) 1 to ID 16 of 4-byte (32-bit) configuration used as address data is attached to main data (sector data) together with an error detection code (IED : ID error detection code) of 2-byte configuration in each sector, and lateral ECCs (error correction codes) 1 and longitudinal ECCs 2 used as error correction codes for reproducing data recorded in the ECC blocks are recorded. The ECCs 1 and 2 are error correction codes attached to data as redundant words for preventing data from being made un-reproducible due to the defect of the optical disk 1.

A preset number of ECC blocks among a plurality of ECC blocks of the zones 3a, • • •, 3x of the data area 3 are used for replacement.

Each of the sectors is constructed by data of 172 bytes × 12 rows, a lateral ECC 1 of 10-byte configuration is attached for each row and a longitudinal ECC 2 of 182-byte configuration of one row is attached to each sector.

When the ECC block is recorded on the optical disk 1, synchronization codes (2 bytes : 32 channel bits) for attaining the byte synchronization when data is reproduced are attached for every preset amount of data (at preset data length intervals, for example, for every 91 bytes : for every 1456 channel bits) of each sector as shown in FIG. 6.

As shown in FIG. 7, each sector is constructed by 26 frames of zero frame to 25th frame and a sync. code (frame synchronization code) attached to each frame is constructed by a specified code (one byte : 16 channel bits) and a common code (one byte : 16 channel bits) which is common for each frame.

That is, as shown in FIG. 7, the zero frame is represented by SY0. the second, tenth and eighteenth frames are represented by SY1, the fourth, twelfth and twentieth frames are represented by SY2, the sixth, fourteenth and twenty-second frames are represented by SY3, the eighth, sixteenth and twenty-fourth frames are represented by SY4, the first, third, fifth, seventh and ninth frames are represented by SY5, the eleventh, thirteenth, fifteenth and seventeenth frames are represented by SY6, and the nineteenth, twenty-first, twenty-third and twenty-fifth frames are represented by SY7.

As shown in FIG. 2, in the tracks of the zones 3a, • • •, 3x of the data area 3, header portions (address field) 11, • • • in which addresses and the like are recorded are previously preformatted for respective sectors.

The header portion 11 is formed at the time of formation of the grooves. As shown in FIG. 8, the header portion 11 is formed of a plurality of pits 12 and pre-formatted for the grooves 13, and the center of the pit 12 lies on the same line as the boundary line between the groove 13 and the land 14.

As shown in FIG. 8, a pit train ID1 constructs the header portion of a groove 1, a pit train ID2 constructs the header portion of a land 1, a pit train ID3 constructs the header portion of a groove 2, a pit train ID4 constructs the header portion of a land 2, a pit train ID5 constructs the header portion of a groove 3, and a pit train ID6 constructs the header portion of a land 3.

Thus, the header portions for grooves and the header portions for lands are alternately (in a staggered form) arranged.

The format for each sector is shown in FIG. 9.

In FIG. 9, one sector is constructed by 2697 bytes and is constructed by a header field of 128 bytes (corresponding to the header portion 11), a mirror field 17 of 2 bytes and a recording field 18 of 2567 bytes.

Channel bits recorded in the above sector are formed in a format obtained by converting 8-bit data into 16-bit channel bits by subjecting the same to the 8-16 code modulation.

The header field 11 is an area in which preset data is recorded at the manufacturing time of the optical disk 1. The header field 11 is constructed by a header 1 field, header 2 field, header 3 field, and header 4 field.

Each of the header 1 field to header 4 field is constructed by 46 bytes or 18 bytes and includes a 36-byte or 8-byte sync. code portion VFO (Variable Frequency Oscillator), 3-byte address mark AM (Address Mark), 4-byte address portion PID (Position Identifier), 2-byte error detection code IED (ID Error Detection Code), and 1-byte postamble PA (Postambles).

Each of the header 1 field and header 3 field includes 36-byte sync. code portion VFO1 and each of the header 2 field and header 4 field includes 8-byte sync. code portion VFO2.

The sync. code portions VFO1, VFO2 are areas used for the pull-in operation of PLL, the sync. code portion VFO1 is formed by recording successive data items of "010 • • •" in channel bits by "36" bytes (576 bits in terms of channel bits) (by recording patterns at preset intervals) and the sync. code portion VFO2 is formed by recording successive data items of "010 • • •" in channel bits by "8" bytes (128 bits in terms of channel bits).

The address mark AM is a sync. code of "3" bytes indicating the position at which the sector address starts. As the pattern of each byte of the address mark AM, a special pattern which does not appear in a data portion of "010010000000100" is used.

The address portions PDI1 to PDI4 are areas in which sector addresses (containing ID numbers) as 4-byte address information are recorded. The sector address is a physical sector number as a physical address indicating the physical position on the track, and since the physical sector number is recorded in the mastering step, it is impossible to rewrite the same.

The ID number is "1" in the case of PID1, for example, and is a number indicating the number of the time among the four times by which the address portion is overwritten in one header portion 11.

The error detection code IED is an error detection

code for the sector address (containing the ID number) and can be used to detect the presence or absence of an error in the readout PID.

The postamble PA contains state information necessary for demodulation and has a role for polarity adjustment so as to cause the header portion 11 to terminate in a space.

The mirror field 17 is used for offset compensation for a tracking error signal, timing control of a land/groove switching signal and the like.

The recording field 18 is constructed by a gap field of 10 to 26 bytes, guard 1 field of 20 to 26 bytes, VFO 3 field of 35 bytes, play synchronous code (PS) field of 3 bytes, data field of 2418 bytes, postamble 3 (PA3) field of one byte, guard 2 field of 48 to 55 bytes and buffer field of 9 to 25 bytes.

The gap field is an area in which nothing is written.

The guard 1 field is an area provided for preventing the terminal deterioration inherent to the phase changing type recording medium occurring at the time of repetitive recording from giving any influence to the VFO 3 field.

The VFO 3 field is an area for PLL locking and is also used for inserting a sync. code into the same pattern and attaining the synchronization of the byte boundary.

The PS (pre-synchronous code) field is a synchronization area for connection to the data field.

The data field is an area constructed by data ID, data ID error correction code IED (Data ID Error Detection Code), sync. code, ECC (Error Correction Code), EDC (Error Detection Code), user data and the like. The data ID includes sector ID1 to sector ID16 of 4-byte configuration (32 channel bits) of each sector. The data ID error correction code IED is an error correction code of 2-byte configuration (16 bits) for data ID.

The sector ID (1 to 16) is constructed by 1-byte (8-bit) sector information and 3-byte sector number (logical sector number as a logical address indicating the logical position on the track). The sector information is constructed by a 1-bit sector format type field, 1-bit tracking method field, 1-bit reflectance field, 1-bit reserve field, 2-bit area type field, 1-bit data type field and 1-bit layer number field.

The logical sector number is made different from the physical sector number by the slip replacement process as will be described later.

When "1" is recorded in the sector format type field, it indicates a zone format type. When "1" is recorded in the tracking method field, it indicates the groove tracking. When "1" is recorded in the reflectance field, it indicates that the reflectance is more than 40%. When "00" is recorded in the area type field, it indicates a data area, when "01" is recorded, it indicates a lead-in area, when "10" is recorded, it indicates a lead-out area, and when "11" is recorded, it indicates "reserve". When "0" is recorded in the data type field, it indicates recording of read only data and when "1" is recorded, it indicates recording of rewritable data. When "0" is recorded in the layer number field, it indicates "layer 0".

The PA (postamble) 3 field is an area containing state information necessary for demodulation and indicating the end of the final byte of a preceding data field.

The guard 2 field is an area provided for preventing the terminal deterioration inherent to the phase changing type recording medium occurring at the time of repetitive recording from giving any influence to the data field.

The buffer field is an area provided for absorbing a fluctuation in the rotating motion of the motor which rotates the optical disk 1 so as to prevent the data field from extending to the next header portion 11.

The reason why the gap field is represented by 10 to 26 bytes is to permit the random shifting operation to be effected. The random shifting operation is to shift the starting position of data to be written so as to reduce a deterioration in the phase changing type recording medium due to the repetitive recording operation. The length of the random shifting is adjusted according to the length of the buffer field arranged in the last portion of the data field, and the whole length of one sector is 2697 bytes and is constant.

In the respective zones 3a, • • •, 3x of the data area 3, spare sectors are prepared and each of them is used as a final spare when the slip replacement process (slipping replacement algorithm) in units of one sector is effected in the same zone.

As shown in FIG. 10, in the replacement management area 6a of the rewritable data zone 6, a primary defect list (PDL) 15 and secondary defect list (SDL) 16 are to be recorded.

The primary defect list (PDL) 15 is a list of physical sector numbers (physical addresses) of sectors which are determined as defective at the manufacturing time or at the initial time such as the application starting time. The sector numbers indicate sectors to be subjected to the replacement process (slipping replacement algorithm) by the slipping process in units of one sector.

In the primary defect list 15, primary defect list identification data, the number of addresses as the number of defects, and physical sector numbers indicating defective sectors are described.

The secondary defect list (SDL) 16 is a list for ECC blocks (defective blocks) having sectors which are determined as defective at the recording time other than the above initial time. That is, it is a list of the physical sector numbers (physical addresses) of the first or head sectors of ECC blocks (defective blocks) having sectors which are determined as defective when data is recorded for preset ECC blocks and the physical sector numbers (physical addresses) of the first sectors of ECC blocks (replacement blocks: spare blocks) which are used for replacement for the defective blocks.

In the secondary defect list, secondary defect list identification data, the number of entries as the number of defects, physical sector numbers indicating first sectors as the addresses of defective blocks and physical sector numbers indicating the first sectors as the

addresses of replacement blocks for the defective blocks are described. The addresses of the defective blocks and the addresses of the replacement blocks for the defective blocks are described in one-to-one correspondence.

In the optical disk device of FIG. 1, the optical disk 1 is rotated at different rotation speeds in the respective zones, for example, by a motor 23. The motor 23 is controlled by a motor control circuit 24.

Recording of data on the optical disk 1 or reproduction of data recorded on the optical disk 1 are effected by an optical head 25. The optical head 25 is fixed on a driving coil 27 constructing a movable portion of a linear motor 26 and the driving coil 27 is connected to a linear motor control circuit 28.

A speed detector 29 is connected to the linear motor control circuit 28 and a speed signal of the optical head 25 is supplied to the linear motor control circuit 28.

A permanent magnet (not shown) is disposed on the fixed portion of the linear motor 26 and when the driving coil 27 is excited by the linear motor control circuit 28, the optical head 25 is moved in the radial direction of the optical disk 1.

In the optical head 25, an objective 30 is supported by use of a wire or flat spring (not shown), and the objective 30 can be moved in a focusing direction (in an optical axis direction of the lens) by a driving coil 31 and moved in a tracking direction (in a direction perpendicular to the optical axis of the lens) by a driving coil 32.

A semiconductor laser oscillator 39 is driven by a laser control circuit 33 to generate laser light. The laser control circuit 33 corrects an amount of laser light from the semiconductor laser oscillator 39 according to a monitoring current from a monitoring photodiode PD of the semiconductor laser oscillator 39.

The laser control circuit 33 is operated in synchronism with a recording clock signal from a PLL circuit (not shown). The PLL circuit divides the frequency of a basic clock signal from an oscillator (not shown) to generate a recording clock signal.

The laser light generated from the semiconductor laser oscillator 39 driven by the laser control circuit 33 is applied to the optical disk 1 via a collimator lens 40, half-prism 41, and objective 30 and the reflection light from the optical disk 1 is directed to a photodetector 44 via the objective 30, half-prism 41, condenser lens 42 and cylindrical lens 43.

The photodetector 44 is constructed by four-divided photodetector cells 44a, 44b, 44c, 44d.

An output signal of the photodetector cell 44a of the photodetector 44 is supplied to one input terminal of an adder 46a via an amplifier 45a, an output signal of the photodetector cell 44b is supplied to one input terminal of an adder 46b via an amplifier 45b, an output signal of the photodetector cell 44c is supplied to the other input terminal of the adder 46a via an amplifier 45c, and an output signal of the photodetector cell 44d is supplied to the other input terminal of the adder 46b via an amplifier 45d.

Further, the output signal of the photodetector cell 44a of the photodetector 44 is supplied to the one input terminal of the adder 46c via the amplifier 45a, the output signal of the photodetector cell 44b is supplied to the one input terminal of the adder 46d via the amplifier 45b, the output signal of the photodetector cell 44c is supplied to the other input terminal of the adder 46d via the amplifier 45c, and the output signal of the photodetector cell 44d is supplied to the other input terminal of the adder 46c via the amplifier 45d.

An output signal of the adder 46a is supplied to an inverting input terminal of a differential amplifier OP2 and an output signal of the adder 46b is supplied to a non-inverting input terminal of the differential amplifier OP2. Therefore, the differential amplifier OP2 supplies a signal (focusing error signal) relating to the point of focus to a focusing control circuit 47 according to a difference between the output signals of the adders 46a and 46b. An output signal of the focusing control circuit 47 is supplied to the focusing driving coil 31 and controlled so as to cause the laser light to be always exactly focused on the optical disk 1.

An output signal of the adder 46c is supplied to an inverting input terminal of a differential amplifier OP1 and an output signal of the adder 46d is supplied to a non-inverting input terminal of the differential amplifier OP1. Therefore, the differential amplifier OP1 supplies a tracking error signal to a tracking control circuit 48 according to a difference between the output signals of the adders 46c and 46d. The tracking control circuit 48 creates a track driving signal according to a tracking error signal supplied from the differential amplifier OP1.

The track driving signal output from the tracking control circuit 48 is supplied to the driving coil 32 for driving the objective in the tracking direction. Further, the tracking error signal used in the tracking control circuit 48 is supplied to the linear motor control circuit 28.

A total sum signal of the output signals of the photodetector cells 44a to 44d of the photodetector 44 obtained after the focusing and tracking operations are effected, that is, a signal obtained by adding together the output signals of the adders 46c and 46d in an adder 46e reflects a variation in the reflectance of a pit (recorded data) formed on the track. The signal is supplied to a data reproducing circuit 38 and recorded data is reproduced in the data reproducing circuit 38.

Reproduced data reproduced in the data reproducing circuit 38 is subjected to the error correction process in an error correction circuit 52 by use of an attached error correction code ECC and then output to an optical disk control circuit 56 used as an external device via an interface circuit 55.

Further, while the objective 30 is being moved by the tracking control circuit 48, the linear motor control circuit 28 drives the linear motor 26 or the optical head 25 so as to set the objective 30 in or near the central position in the optical head 25.

In the preceding stage of the laser control circuit 33, a data creation circuit 34 is provided. The data creation

circuit 34 includes an ECC block data creation circuit 34a for converting ECC block format data used as recording data as shown in FIG. 5 and supplied from the error correction circuit 52 into recording ECC block format data having ECC block sync. codes attached thereto as shown in FIG. 6 and a modulation circuit 34b for modulating recording data from the ECC block data creation circuit 34a according to the 8-16 code conversion system.

The data creation circuit 34 is supplied with recording data having an error correction code attached thereto by the error correction circuit 52 and dummy data for error checking read out from the memory 10. The error correction circuit 52 is supplied with recording data from the optical disk control device 56 used as an external device via the interface circuits 55 and a bus 49.

The error correction circuit 52 creates ECC block format data as shown in FIG. 5 by attaching error correction codes (ECC1, ECC2) for lateral and longitudinal directions of recording data items which are set in units of one sector of 2k bytes and included in the 32k-byte recording data supplied from the optical disk control device 56 and attaching sector IDs (logical address numbers) to the respective recording data items.

Further, in the optical disk device, a D/A converter 51 used for transferring information between a CPU 50 for controlling the whole portion of the optical disk device and the focusing control circuit 47, tracking control circuit 48 and linear motor control circuit 28 is provided.

The motor control circuit 24, linear motor control circuit 28, laser control circuit 33, data reproducing circuit 38, focusing control circuit 47, tracking control circuit 48, and error correction circuit 53 are controlled by the CPU 50 via the bus 49 and the CPU 50 performs preset operations according to control programs stored in the memory 10.

The memory 10 is used for storing the control programs and data. The memory 10 includes a table 10a in which speed data items as rotation speeds for the zones 3a, • • •, 3x and the number of sectors for each track are recorded and a table 10b in which the primary defect list (PDL) 15 and secondary defect list (SDL) 16 read out from the replacement management area 6a of the optical disk 1 are recorded.

As shown in FIGS. 1 and 11, a detector 21 for detecting the presence or absence of a cartridge 20 into which the optical disk 1 is received and a detector 22 for detecting the presence or absence of a through hole 20a of the cartridge 20 are disposed below the optical disk 1. The detectors 21, 22 are each constructed by a microswitch, for example.

The cartridge 20 is formed to receive the optical disk 1, and if the cartridge 20 is opened at least once (if the optical disk 1 is taken out), the through hole 20a is formed in the cartridge. Detection signals from the detectors 21, 22 are supplied to the CPU 50 via the bus 49.

The CPU 50 determines whether the cartridge 20 is present or not according to the detection signal from the detector 21. Further, when it is determined that the cartridge 20 is present, the CPU 50 determines whether the cartridge 20 is opened at least once or not according to the detection signal from the detector 22.

Next, the primary defect list forming process effected at the manufacturing time or the initial time such as the application starting time is explained with reference to the flowchart of FIG. 12.

Assuming now that the optical disk 1 at the application starting time is loaded on the optical disk device, then the CPU 50 determines the slip replacement process to read out dummy data from the memory 10 and control the recording operation for each sector of the data area 3 of the optical disk 1 by use of the dummy data (ST1).

Therefore, while the optical disk 1 is being rotated at a rotation speed different for each zone of the data area 3, the laser control circuit 33 is controlled by a signal obtained by modulating the dummy data and output from the data creation circuit 34 to drive the semiconductor laser oscillator 39 so that laser light corresponding to the modulated signal of the dummy data will be applied to the optical disk 1. As a result, data corresponding to the modulated signal of the dummy data is recorded in the data field of each sector of the data area 3 of the optical disk 1.

After this, when the recording operation for each sector of the data area 3 of the optical disk 1 is terminated, the CPU 50 controls the readout of dummy data for each sector (ST2).

Therefore, while the optical disk 1 is being rotated at a rotation speed different for each zone of the data area 3, reflection light based on the reproducing laser light from the semiconductor laser oscillator 39 is directed to the photodetector 44 so that the physical sector number recorded in the header portion 11 of each sector can be reproduced by the data reproducing circuit 38 and data recorded in the data field of the sector can be demodulated and reproduced.

Based on the above reproduction, the CPU 50 determines that data is correctly recorded in a case where the physical sector number of the header portion 11 of each sector can be correctly reproduced or when the recorded dummy data is compared with the reproduced data and it is determined that the number of errors in the sector does not exceed a first specified value and the CPU 50 further determines occurrence of primary defect (initial defect) due to the fact that data is not correctly recorded and determines it as an object of the slip replacement process in a case where the physical sector number in the header portion 11 cannot be correctly reproduced or the number of errors in the sector exceeds the first specified value (ST3).

The first specified value is determined such that the number of rows containing, for example, four or more error bytes in one sector having a configuration of 182 bytes × 13 rows is set to five or more.

As the result of above determination, if the CPU 50 determines the defect as an object of the slip replacement process, the CPU determines the sector as a defective sector and stores the physical sector number thereof as a defective sector into the memory 10 (ST4).

Then, when the process for checking all of the sectors in the data area 3 is completed (ST5), the CPU 50 controls the recording operation for the replacement management area 6a of the optical disk 1 according to data dealt with as a primary defect list containing primary defect list identification information and the number of physical sector numbers attached to the physical sector numbers of the defective sectors stored in the memory 10 (ST6).

Therefore, while the optical disk 1 is being rotated at a rotation speed corresponding to the data zone 6, the laser control circuit 33 is controlled by a signal obtained by modulating data supplied as the primary defect list from the data creation circuit 34 to drive the semiconductor laser oscillator 39 so that laser light corresponding to the modulated signal of data as the primary defect list will be applied to the optical disk 1. As a result, data corresponding to the modulated signal of data dealt with as the primary defect list is recorded in the replacement management zone 6a of the data area 3 of the optical disk 1.

Next, the slip replacement process (slipping replacement algorithm) effected in units of one sector based on the primary defect list is explained with reference to FIGS. 13, 14, 15.

That is, when data is recorded in units of one ECC block on the optical disk 1, the slip replacement process in units of one sector is effected by slipping or skipping over the defective sector based on the primary defect list.

For example, assuming now that data of one ECC block is recorded by use of 16 sectors ranging from the physical sector number (m-1) to the physical sector number (m+14) of the optical disk 1, then data of one ECC block is recorded by use of 16 sectors ranging from the physical sector number (m-1) to the physical sector number (m+15) except the sector of the physical sector number m if the sector of the physical sector number m in the above sectors is registered in the primary defect list.

In this case, if "m-1" is attached as the logical sector number for the physical sector number (m-1) as shown in FIGS. 13 and 14, the logical sector number m is recorded for the physical sector number (m+1), the logical sector number (m+1) is recorded for the physical sector number (m+2), the logical sector number (m+2) is recorded for the physical sector number (m+3), the logical sector number (m+3) is recorded for the physical sector number (m+4), the logical sector number (m+4) is recorded for the physical sector number (m+5), the logical sector number (m+5) is recorded for the physical sector number (m+6), the logical sector number (m+6) is recorded for the physical sector number (m+7), the logical sector number (m+7) is recorded for the physical sector number (m+8), the logical sector number (m+8) is recorded for the physical sector number (m+9), the logical sector number (m+9) is recorded for the physical sector number (m+10), the logical sector number (m+10) is recorded for the physical sector number (m+11), the logical sector number (m+11) is recorded for the physical sector number (m+12), the logical sector number (m+12) is recorded for the physical sector number (m+13), the logical sector number (m+13) is recorded for the physical sector number (m+14), and the logical sector number (m+14) is recorded for the physical sector number (m+15).

Therefore, as shown in FIG. 15, if the slip replacement process in units of one sector is effected in the ECC block n in the ECC blocks (n-1), n, (n+1), (n+2), • • • in which successive data items such as moving pictures are recorded, the recording operation only for the defective sector contained in the ECC block n is interrupted and the relation between the physical sector and the ECC block (logical sector) in which data is recorded is shifted by one sector.

As a result, if successive data items such as moving pictures and speeches are recorded in the above ECC block, interruption of the reproduction due to the presence of the defective sector occurs, but since the period of interruption of the reproduction for one sector is short, no substantial influence will be given to the reproduced pictures and speeches.

It is understood that the period of interruption is relatively short in comparison with a case wherein the recording operation is interrupted for a period of one ECC block if the slip replacement process is effected in units of one ECC block as in the prior art. Thus, successive data items can be recorded almost without interruption.

Since the slip replacement process in units of one sector is effected based on the primary defect list, physical sectors for each ECC block are allocated and the relation of the physical sectors with respect to the logical sectors for each ECC block is determined and stored in the memory 10 when the optical disk 1 is loaded on the optical disk device and the primary defect list read out from the replacement management area 6a of the optical disk 1 is recorded in the table 10b of the memory 10.

Next, the linear replacement process (linear replacement algorithm) in units of one ECC block is explained with reference to FIGS. 16, 17 and 18.

For example, assume now that successive data items such as moving pictures or speeches are recorded in the ECC blocks which are successive on the optical disk 1 or in the ECC block (n-1), ECC block (n), ECC block (n+1), ECC block (n+2), • • • as shown in FIG. 16.

If it is determined that a secondary defect occurs in one of the sectors of the ECC block (n) at the actual data recording time, the ECC block (n) containing the secondary defective sector is replaced by a replacement ECC block (l) by the linear replacement process in

units of one block and then corresponding data is recorded therein. At this time, data indicating that the linear replacement process has been effected is recorded in the memory 10. The order of reproduction of the thus recorded data items is set such that the ECC block (n-1) is first reproduced, then the ECC block (l) for replacement is reproduced, the ECC block (n+1) is next reproduced, and the ECC block (n+2) is reproduced as shown in FIG. 17.

In this case, unlike the conventional case, it is not necessary to effect the replacement process in units of one sector, that is, it is not necessary to access the ECC block for replacement in the course of reproduction of one ECC block, then return to the original ECC block and continue the reproducing operation for the original ECC block, and thus the reproduction speed which is sufficiently high so as not to cause any harmful influence can be attained.

In a case where the replacement process in units of one ECC block is effected and if the logical sector numbers m to (m+15) and the physical sector numbers m to (m+15) of the sectors in the ECC block (n) containing the secondary defective sector are obtained before the linear replacement process as shown in FIG. 18, then the logical sector numbers m to (m+15) are attached to the physical sector numbers y to (y+15) of the sectors in the replacement ECC block (l) after completion of the linear replacement process.

In other words, the logical sector number of the recording field 18 to be replaced is recorded as the address data of the replacing recording field 18, and this recording operation is performed without reference to the address data (physical sector number) stored in the replacing header field 11.

Next, the process effected when data is recorded into a preset ECC block is explained with reference to the flowcharts shown in FIGS. 19 and 20.

For example, assume now that recording data and specification of recording of data into the preset ECC block in the data area 3 of the optical disk 1 are supplied from the optical disk control device 56 to the optical disk device via the interface circuit 55. Then, the specification of recording of data into the preset ECC block is supplied to the CPU 50 and recording data of sector unit obtained by attaching an error correction code to the above recording data by the error correction circuit 52 is supplied to the data creation circuit 34 (ST10).

At the time of loading of the optical disk 1, the CPU 50 reads out the primary defect list and secondary defect list recorded in the replacement management area 6a of the optical disk 1, records them in the table 10b of the memory 10, and determines and records physical sector numbers (the primary defective sector is already slipped over) of the respective sectors for the ECC block based on the primary defect list (ST11).

Further, the CPU 50 rotates the optical disk 1 at a rotation speed corresponding to the zone in which the ECC block to be recorded is contained (ST12).

In this state, when the physical sector number of the first sector of the ECC block is obtained by reproduction of the head portion 11, the data creation circuit 34 converts ECC block format data (first one sector) used as recording data into format data of recording ECC block to which sync. codes for ECC block are attached, subject the same to the 8-16 code modulation and then outputs the resultant data to the laser control circuit 33. The semiconductor laser oscillator 39 is driven by the laser control circuit 33 to apply laser light corresponding to the modulated signal of ECC block format data to the optical disk 1. As a result, data is recorded in the first sector of the preset ECC block of the data area 3 of the optical disk 1 (ST13).

After this, data of sector unit is recorded in the same manner as described above (ST13) each time a physical sector number corresponding to the physical sector number specified by the CPU 50 is reproduced.

At this time, data is recorded based on the physical sector numbers of the sectors for the ECC block based on the primary defect list recorded in the memory 10. That is, data is recorded while effecting the above-described slip replacement process to slip or skip over the defective sector.

When recording of data into the preset ECC block is completed, the CPU 50 determines the presence or absence (loaded state or not) of the cartridge 20 according to a detection signal from the detector 21 (ST14), and if the presence of the cartridge 20 is determined, the CPU 50 determines whether the cartridge 20 has been opened at least once or not according to a detection signal from the detector 22 (ST15).

Based on the result of the above determination, if the loading of the cartridge 20 which is not opened even once is determined, the CPU 50 determines that it is not necessary to check the recording data and completes the data recording process (ST16).

If the loading of the cartridge 20 is not determined in the step ST14 or if the loading of the cartridge 20 is determined and it is determined that the cartridge 20 is opened at least once, the CPU 50 controls the data readout for each sector of the ECC block (ST17).

As a result, reflection light based on laser light for reproduction from the semiconductor laser oscillator 39 is directed to the photodetector 44 and the data reproducing circuit 38 reproduces the physical sector numbers recorded in the header portions 11 of the sectors subjected to the above recording operation and demodulates and reproduces data recorded in the data fields of the respective sectors (ST18).

Based on the above reproduction, the CPU 50 determines that data is correctly recorded in a case where the physical sector number of the header portion 11 of each sector can be correctly reproduced or when the recorded data of each sector is compared with the reproduced data of each sector and it is determined that the number of errors in the sector does not exceed a preset specified value and the CPU 50 further determines occurrence of the secondary defect due to the fact that data is not correctly recorded and determines it

as an object of the linear replacement process in a case where the physical sector number in the header portion 11 cannot be correctly reproduced or the number of errors in the sector exceeds the preset specified value (ST19).

For determination of the error state in the sector, one of the following four conditions is used.

The first condition is that the physical sector number in the header portion 11 cannot be correctly reproduced.

The second condition is that the number of errors in at least one sector exceeds a first specified value.

The third condition is that the number of errors in at least one sector does not exceed the first specified value but exceeds a second specified value and the number of errors in the whole ECC block exceeds a third specified value.

The fourth condition is that the number of errors in at least one sector does not exceed the first specified value but exceeds the second specified value and the number of errors in the sectors of the whole ECC block exceeds a fourth specified value.

The reason why the third and fourth conditions are set as an object of the linear replacement process is that data can be corrected in the whole ECC block even when a large number of errors occur and if they occur only in one sector in the ECC block. The ECC block has 208 rows as a whole and data of up to 16 rows each including five or more errors can be corrected. Under this condition, the above specified values are determined.

That is, the first specified value is determined such that the number of rows containing, for example, four or more error bytes in one sector having a configuration of 182 bytes × 13 rows is set to five or more.

The second specified value is determined such that the number of rows containing four or more error bytes is set to three or more.

The third specified value is determined such that the number of rows containing four or more error bytes is set to ten or more.

The fourth specified value is set to 2 sectors.

As the result of determination in the step ST19, an object of the linear replacement process is determined, an ECC block determined as an object is treated as a defective block and the above-described linear replacement process for recording data of ECC block unit which is to be recorded in the defective block into a replacement ECC block is effected (ST20), and if an object of the linear replacement process is not determined, the recording process for the data is completed.

If the above linear replacement process is effected, the CPU 50 updates and records the physical sector number (address of the defective block) of the first sector of the defective block and the physical sector number (address of the replacement block) of the first sector of the replacement ECC block on the secondary defect list of the memory 10 and terminates the recording process for the data (ST21).

Further, when the optical disk 1 subjected to the linear replacement process is taken out from the optical disk device or when the secondary defect list recorded on the table 10b is updated, the CPU 50 updates and records the recording content of the secondary defect list of the memory 10 in the replacement management area 6a of the optical disk 1.

As described above, in the optical disk on which data is recorded in units of one ECC block constructed by 16 sectors, dummy data is recorded at the manufacturing time or at the initial time such as the application starting time, the dummy data is reproduced to determine a sector with primary defect, the address of the sector with primary defect is recorded on the optical disk, and data of ECC block unit is recorded at the data recording time while skipping over the sector with primary defect.

As a result, if successive data items such as moving pictures or speeches are recorded in the above ECC block, data reproduction is temporarily interrupted because of the presence of the defective sector, but since the interrupting time of the reproduction for one sector is short, the pictures or speeches to be reproduced will not be influenced.

It is understood that the above interruption time is relatively shorter in comparison with recording interruption time of one ECC block caused when the slip replacement process is effected in units of one ECC block as in the prior art. Thus, successive data items can be recorded almost without interruption.

Further, in the optical disk on which data is recorded in units of one ECC block, data is recorded at the data recording time other than the initial time, the data is reproduced to determine the presence of an ECC block having a sector with secondary defect, and data in the ECC block which is determined to have the sector with secondary defect is recorded in an ECC block which is separately prepared.

Thus, even when the defect replacement process is effected at the recording time after the initial time, a lowering in the reproduction speed can be suppressed.

That is, unlike the conventional case, it is not necessary to effect the replacement process in units of one sector, that is, it is not necessary to access the ECC block for replacement in the course of reproduction of one ECC block, then return to the original ECC block and continue the reproducing operation for the original ECC block, and thus the reproduction speed which is sufficiently high so as not to cause any harmful influence can be attained.

Claims

1. A replacement processing method for an optical disk (1) which has tracks arranged in a concentric or spiral form for data recording and in which a format having a plurality of successive sector areas each having a preset track length and including an address field (11) for recording address data indi-

cating the position on the track and a recording field (18) for recording a recording data is defined, the recording data recording is effected in units of one block area containing a group of a preset number of sector areas among said plurality of sector areas and including an error correction data recording area in which error correction data items used for reproducing data recorded in said preset number of sector areas are collectively recorded for the group of said preset number of sector areas, and each of said sector areas has a plural-byte configuration, comprising the steps of:

recording the recording data and error correction data into said recording field (18) of each of said sector areas on the entire surface of said optical disk (1) at the manufacturing time or at the initial time such as the application starting time;
reproducing the recorded the recording data and error correction data and the address data in units of one sector area;
determining occurrence of a sector area with defect in a case where address data in said address field (11) cannot be reproduced at the time of reproduction or the number of error bytes exceeds a specified value;
recording address data of the sector area which is determined to be defective;
successively recording the recording data and error correction data into a plurality of successive block areas on said optical disk (1); and
skipping over a sector area with defect in units of one sector area based on the recorded address data and recording the recording data and error correction data into a next sector area in a case where the recording data and error correction data is sequentially recorded into said plurality of sector areas in each of said block areas.

2. A replacement processing method according to claim 1, characterized in that address data in said address field (11) is a physical address which is previously recorded and constructed by an un-rewritable embossed pit.

3. A replacement processing method according to claim 1, characterized in that rewritable address data which is a logical address is recorded in said recording field (18).

4. A replacement processing method according to claim 1, characterized in that address data recorded in said address field (11) is an un-rewritable physical address, the un-rewritable physical addresses are sequentially allocated on said optical disk (1), address data recorded in said recording field (18) is a rewritable logical address, and the rewritable logical addresses are allocated on said optical disk (1) while a sector area with defect is skipped over in units of one sector area.

5. A replacement processing method according to claim 1, characterized in that each of said block areas includes 16 sector areas.

6. A replacement processing method according to claim 1, characterized in that said optical disk (1) is rotated and divided into a plurality of zones in the radial direction of a data area (3) on said optical disk (1) and the rotation speed of said optical disk (1) is set to different values for the respective zones.

7. A replacement processing method according to claim 6, characterized in that available sector areas are provided for the respective zones and said block area can be constructed by a preset number of sector areas even if a sector area with defect is skipped over in units of one sector area.

8. A replacement processing method according to claim 1, characterized in that a defect list recording area (6a) in which a list of address data items of the sector areas with defects is recorded is provided on said optical disk (1).

9. An optical disk device for recording data on an optical disk (1) which has tracks arranged in a concentric or spiral form for data recording and in which a format having a plurality of successive sector areas each having a preset track length and including an address field (11) for recording address data indicating the position on the track and a recording field (18) for recording a recording data is defined, the recording data recording is effected in units of one block area containing a group of a preset number of sector areas among said plurality of sector areas and including an error correction data recording area in which error correction data items used for reproducing data recorded in said preset number of sector areas are collectively recorded for the group of said preset number of sector areas, and each of said sector areas has a plural-byte configuration, comprising:

first recording means (25, 33, 50) for recording the recording data and error correction data into said recording field (18) of each of said sector areas on the entire surface of said optical disk (1) at the manufacturing time or at the initial time such as the application starting time;
reproducing means (25, 38, 50) for reproducing the address data in said address field (11) and the recording data and error correction data recorded by said first recording means in units of one sector area;

determining means (50) for determining occurrence of a sector area with defect in a case where address data in said address field (11) cannot be reproduced at the time of reproduction by said reproducing means (25, 38, 50) or the number of error bytes exceeds a specified value;

second recording means (25, 33, 50) for recording address data of the sector area which is determined to be defective by said determining means (50); and

third recording means (25, 33, 50) for successively recording the recording data and error correction data into a plurality of successive block areas on said optical disk (1), and in a case where the recording data and error correction data is sequentially recorded into said plurality of sector areas in each of said block areas, skipping over the sector area with defect in units of one sector area based on address data recorded by said second recording means (25, 33, 50) and then recording the recording data and error correction data into a next sector area.

10. An optical disk device according to claim 9, characterized in that address data in said address field (11) is a physical address which is previously recorded and constructed by an un-rewritable embossed pit.

11. An optical disk device according to claim 9, characterized in that rewritable address data which is a logical address is recorded in said recording field (18).

12. An optical disk device according to claim 9, characterized in that address data recorded in said address field (11) is an un-rewritable physical address, the un-rewritable physical addresses are sequentially allocated on said optical disk (1), address data recorded in said recording field (18) is a rewritable logical address, and the rewritable logical addresses are allocated on said optical disk while a sector area with defect is skipped over in units of one sector area.

13. An optical disk device according to claim 9, characterized in that each of said block areas includes 16 sector areas.

14. An optical disk device according to claim 9, characterized in that said optical disk (1) is rotated and divided into a plurality of zones in the radial direction of a data area (3) on said optical disk (1) and the rotation speed of said optical disk (1) is set to different values for the respective zones.

15. An optical disk device according to claim 14, characterized in that available sector areas are provided for the respective zones and said block area can be constructed by a preset number of sector areas even if a sector area with defect is skipped over in units of one sector area.

16. An optical disk device according to claim 9, characterized in that a defect list recording area (6a) in which a list of address data items of the sector areas with defects is recorded is provided on said optical disk (11).

17. A replacement processing method for an optical disk (1) which has tracks arranged in a concentric or spiral form for data recording and in which a format having a plurality of successive sector areas each having a preset track length and including an address field (11) for recording address data indicating the position on the track and a recording field (18) for recording a recording data is defined, the recording data recording is effected in units of one block area containing a group of a preset number of sector areas among said plurality of sector areas and including an error correction data recording area in which error correction data items used for reproducing data recorded in said preset number of sector areas are collectively recorded for the group of said preset number of sector areas, and each of said sector areas has a plural-byte configuration, comprising the steps of:

successively recording the recording data and error correction data into a plurality of successive block areas on said optical disk (1) and sequentially recording the recording data and error correction data into said plurality of sector areas in each of said block areas at the time other than the manufacturing time or the initial time such as the application starting time;

reproducing the recording data and error correction data and the address data recorded in said sector areas for each of said block areas;

determining occurrence of a block area having a defective sector area with defect in a case where address data in said address field (11) cannot be reproduced at the time of reproduction, where the number of error bytes exceeds a first specified value, where the number of error bytes is not larger than the first specified value and exceeds a second specified value and the number of error bytes in one block area exceeds a third specified value, or where the number of sector areas in which the number of error bytes is not larger than the first specified value and exceeds the second specified value exceeds a fourth specified value in one block area; and

recording the recording data and error correction data in a different block area which is differ-

ent from the block area containing the defective sector area.

18. A replacement processing method according to claim 17, characterized in that address data in said address field (11) is a physical address which is previously recorded and constructed by an un-rewritable embossed pit.

19. A replacement processing method according to claim 17, characterized in that rewritable address data which is a logical address is recorded in said recording field (18).

20. A replacement processing method according to claim 17, characterized in that each of said block areas includes 16 sector areas.

21. A replacement processing method according to claim 17, characterized in that said optical disk (1) is rotated and divided into a plurality of zones in the radial direction of a data area (3) on said optical disk (1) and the rotation speed of said optical disk (1) is set to different values for the respective zones.

22. A replacement processing method according to claim 17, characterized in that said optical disk (1) is provided with a defect list recording area (6a) in which address data of the first sector area of the different block area is recorded in association with the address data of the first sector area of the block area having the defective sector area with a defect.

23. An optical disk device for recording data on an optical disk (1) which has tracks arranged in a concentric or spiral form for data recording and in which a format having a plurality of successive sector areas each having a preset track length and including an address field (11) for recording address data indicating the position on the track and a recording field (18) for recording a recording data is defined, the recording data recording is effected in units of one block area containing a group of a preset number of sector areas among said plurality of sector areas and including an error correction data recording area in which error correction data items used for reproducing data recorded in said preset number of sector areas are collectively recorded for the group of said preset number of sector areas, and each of said sector areas has a plural-byte configuration, comprising:

first recording means (25, 33, 50) for successively recording the recording data and error correction data into a plurality of successive block areas on said optical disk (1) and sequentially recording the recording data and error correction data into said plurality of sector areas in each of said block areas at the time other than the manufacturing time or the initial time such as the application starting time;

reproducing means (25, 38, 50) for reproducing the recording data and error correction data and the address data recorded in said sector areas for each of said block areas by said first recording means (25, 33, 50);

determining means (50) for determining occurrence of a block area having a sector area with defect in a case where address data in said address field (11) cannot be reproduced at the time of reproduction, where the number of error bytes exceeds a first specified value, where the number of error bytes is not larger than the first specified value and exceeds a second specified value and the number of error bytes in one block area exceeds a third specified value, or where the number of sector areas in which the number of error bytes is not larger than the first specified value and exceeds the second specified value exceeds a fourth specified value in one block area; and

second recording means (25, 38, 50) for recording the recording data and error correction data in a different block area which is different form the block area containing the defective sector area.

24. An optical disk device according to claim 23, characterized in that address data in said address field (11) is a physical address which is previously recorded and constructed by an un-rewritable embossed pit.

25. An optical disk device according to claim 23, characterized in that rewritable address data which is a logical address is recorded in said recording field (18).

26. An optical disk device according to claim 23, characterized in that each of said block areas includes 16 sector areas.

27. An optical disk device according to claim 23, characterized in that said optical disk (1) is rotated and divided into a plurality of zones in the radial direction of a data area (3) on said optical disk and the rotation speed of said optical disk (1) is set to different values for the respective zones.

28. An optical disk device according to claim 23, characterized in that said optical disk (1) is provided with a defect list recording area (6a) in which address data of the first sector area of the different block area is recorded in association with the address data of the first sector area of the block area having the defective sector area with a defect.

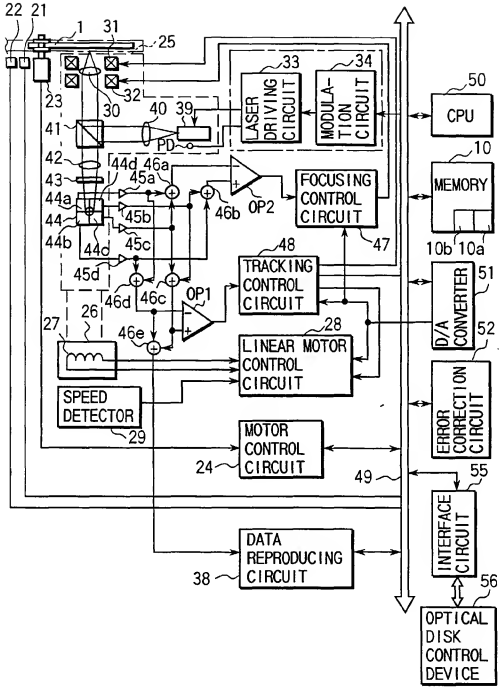
22
21
1
31
25
33
34
LASER DRIVING CIRCUIT
MODULATION CIRCUIT
50
CPU
23
32
30
40
39
41
PD
42
44d
46a
43
45a
44a
45b
46b
OP2
FOCUSING CONTROL CIRCUIT
10
MEMORY
44
45c
47
44b
44c
10b
10a
48
TRACKING CONTROL CIRCUIT
51
D/A CONVERTER
45d
46d
46c
OP1
26
27
46e
28
52
LINEAR MOTOR CONTROL CIRCUIT
ERROR CORRECTION CIRCUIT
SPEED DETECTOR
29
MOTOR CONTROL CIRCUIT
24
49
55
INTERFACE CIRCUIT
DATA REPRODUCING CIRCUIT
38
56
OPTICAL DISK CONTROL DEVICE

FIG. 1

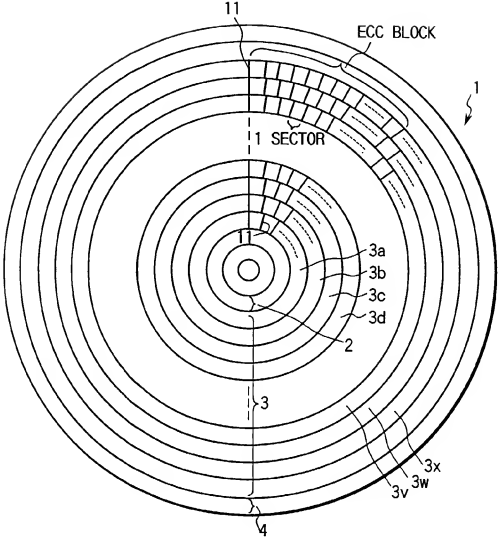

FIG. 2

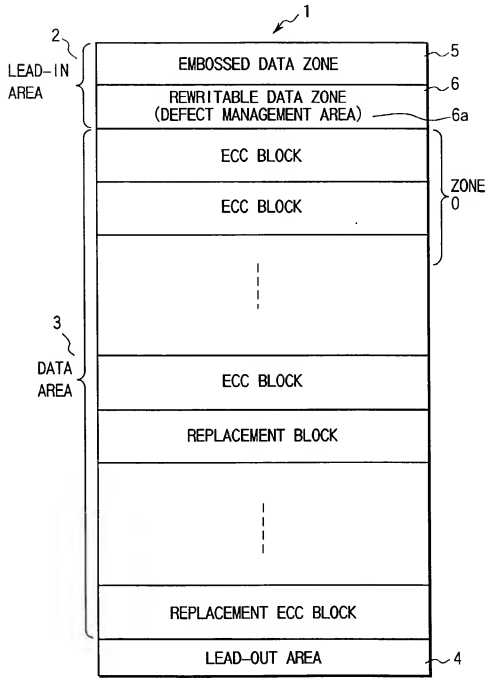
1
2
LEAD-IN AREA
EMBOSSED DATA ZONE
5
REWRITABLE DATA ZONE (DEFECT MANAGEMENT AREA)
6
6a
ECC BLOCK
ECC BLOCK
ZONE 0
3
DATA AREA
ECC BLOCK
REPLACEMENT BLOCK
REPLACEMENT ECC BLOCK
LEAD-OUT AREA
4

FIG. 3

			ROTATION SPEED(Hz)	NUMBER OF SECTORS PAR TRACK
LEAD-IN AREA	EMBOSSED DATA ZONE		37.57	18
	REWRITABLE DATA ZONE(DEFECT MANAGEMENT AREA)		39.78	17
DATA AREA		ZONE 0	39.78	17
		ZONE 1	37.57	18
		ZONE 2	35.59	19
		⋮	⋮	⋮
	3W	ZONE 23	16.91	40
LEAD-OUT AREA			16.91	40

10a

FIG. 4

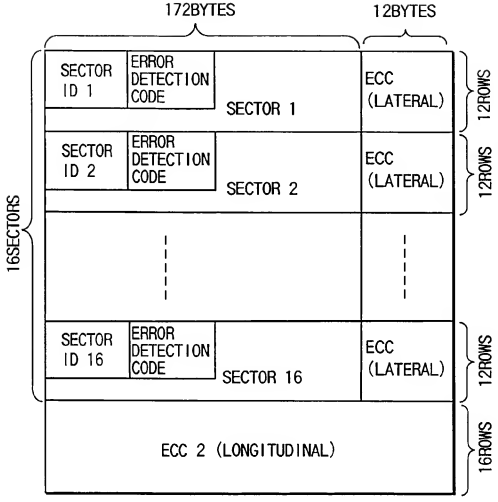
172BYTES
12BYTES
SECTOR ID 1
ERROR DETECTION CODE
SECTOR 1
ECC (LATERAL)
12ROWS
SECTOR ID 2
ERROR DETECTION CODE
SECTOR 2
ECC (LATERAL)
12ROWS
16SECTORS
SECTOR ID 16
ERROR DETECTION CODE
SECTOR 16
ECC (LATERAL)
12ROWS
ECC 2 (LONGITUDINAL)
16ROWS

FIG. 5

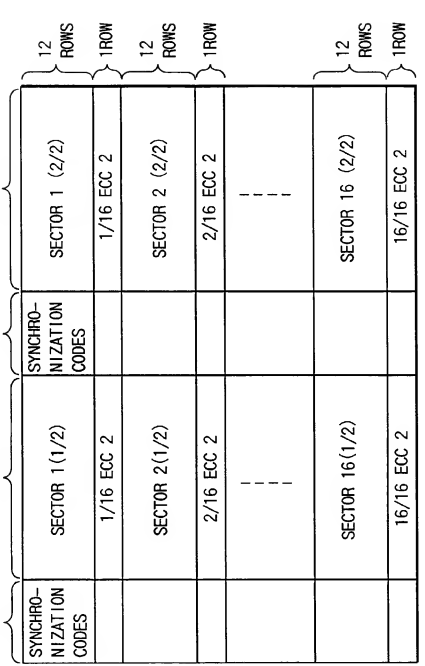
2BYTE
91BYTES
2BYTE
91BYTES
SYNCHRO-NIZATION CODES
SECTOR 1(1/2)
SYNCHRO-NIZATION CODES
SECTOR 1 (2/2)
12 ROWS
1/16 ECC 2
1/16 ECC 2
1ROW
SECTOR 2(1/2)
SECTOR 2 (2/2)
12 ROWS
2/16 ECC 2
2/16 ECC 2
1ROW
SECTOR 16(1/2)
SECTOR 16 (2/2)
12 ROWS
16/16 ECC 2
16/16 ECC 2
1ROW

FIG. 6

	SYNC FRAME		SYNC FRAME	
	32CHANNEL BITS (2BYTES)	1456CHANNEL BITS (91BYTES)	32CHANNEL BITS (2BYTES)	1456CHANNEL BITS (91BYTES)
13 ROWS	SY0	ZERO FRAME	SY5	FIRST FRAME
	SY1		SY5	
	SY2		SY5	
	SY3		SY5	
	SY4		SY5	
	SY1		SY6	
	SY2		SY6	
	SY3		SY6	
	SY4		SY6	
	SY1		SY7	
	SY2		SY7	
	SY3		SY7	
	SY4		SY7	

FIG. 7

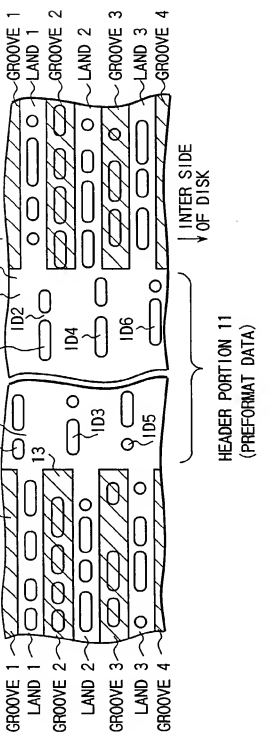
OUTER SIDE OF DISK
INTER SIDE OF DISK
GROOVE 1
LAND 1
GROOVE 2
LAND 2
GROOVE 3
LAND 3
GROOVE 4
ID1
ID2
ID3
ID4
ID5
ID6
11
12
13
14
HEADER PORTION 11
(PREFORMAT DATA)

FIG. 8

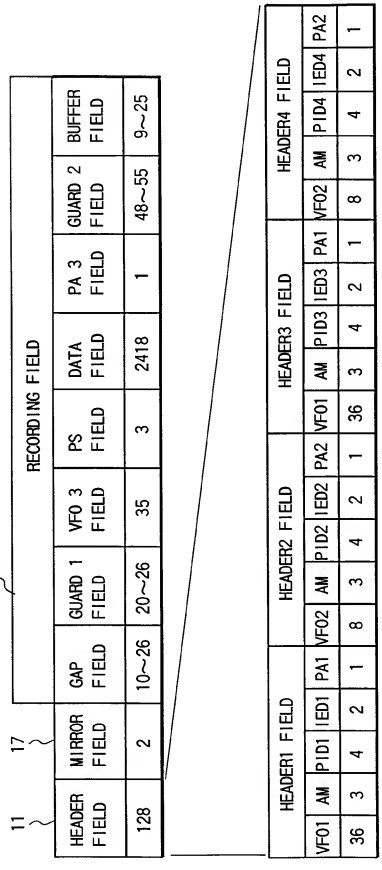
11
17
18
RECORDING FIELD
HEADER FIELD
MIRROR FIELD
GAP FIELD
GUARD 1 FIELD
VFO 3 FIELD
PS FIELD
DATA FIELD
PA 3 FIELD
GUARD 2 FIELD
BUFFER FIELD
128
2
10~26
20~26
35
3
2418
1
48~55
9~25
HEADER1 FIELD
HEADER2 FIELD
HEADER3 FIELD
HEADER4 FIELD
VFO1 AM PID1 IED1 PA1 VFO2 AM PID2 IED2 PA2 VFO1 AM PID3 IED3 PA1 VFO2 AM PID4 IED4 PA2
36 3 4 2 1 8 3 4 2 1 36 3 4 2 1 8 3 4 2 1

FIG. 9

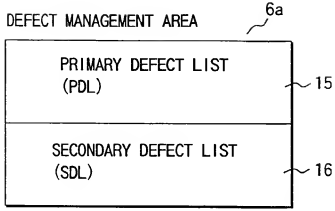
DEFECT MANAGEMENT AREA
6a
PRIMARY DEFECT LIST
(PDL)
15
SECONDARY DEFECT LIST
(SDL)
16

FIG. 10

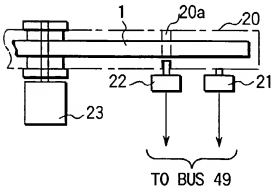
1
20a
20
22
21
23
TO BUS 49

FIG. 11

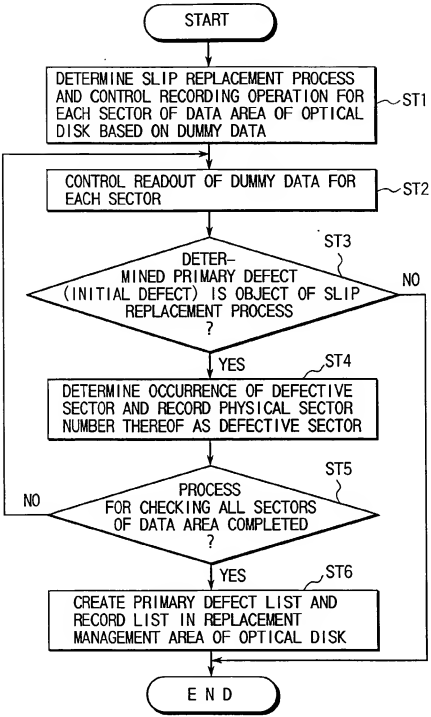
START
DETERMINE SLIP REPLACEMENT PROCESS AND CONTROL RECORDING OPERATION FOR EACH SECTOR OF DATA AREA OF OPTICAL DISK BASED ON DUMMY DATA
ST1
CONTROL READOUT OF DUMMY DATA FOR EACH SECTOR
ST2
ST3
DETER-MINED PRIMARY DEFECT (INITIAL DEFECT) IS OBJECT OF SLIP REPLACEMENT PROCESS ?
NO
YES
ST4
DETERMINE OCCURRENCE OF DEFECTIVE SECTOR AND RECORD PHYSICAL SECTOR NUMBER THEREOF AS DEFECTIVE SECTOR
ST5
PROCESS FOR CHECKING ALL SECTORS OF DATA AREA COMPLETED ?
NO
YES
ST6
CREATE PRIMARY DEFECT LIST AND RECORD LIST IN REPLACEMENT MANAGEMENT AREA OF OPTICAL DISK
END

FIG. 12

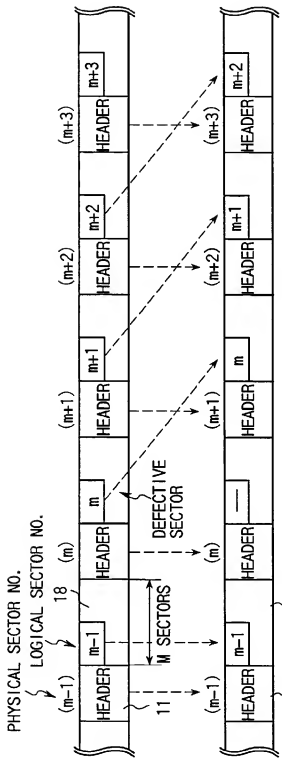
PHYSICAL SECTOR NO.
LOGICAL SECTOR NO.
(m-1)
18
(m)
(m+1)
(m+2)
(m+3)
HEADER
m-1
m
m+1
m+2
m+3
M SECTORS
DEFECTIVE SECTOR
11
18

FIG. 13

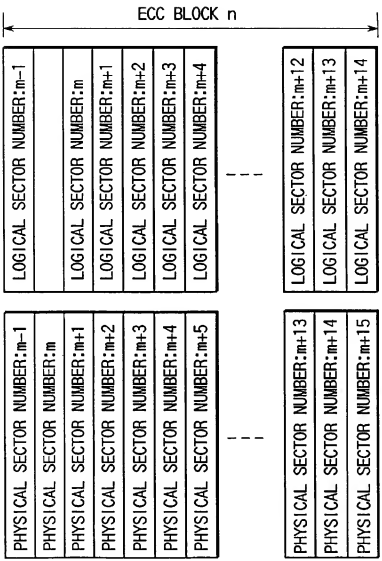
ECC BLOCK n
SECTOR NUMBER OF HEADER PORTION
SECTOR NUMBER OF DATA PORTION
PHYSICAL SECTOR NUMBER:m-1
PHYSICAL SECTOR NUMBER:m
PHYSICAL SECTOR NUMBER:m+1
PHYSICAL SECTOR NUMBER:m+2
PHYSICAL SECTOR NUMBER:m+3
PHYSICAL SECTOR NUMBER:m+4
PHYSICAL SECTOR NUMBER:m+5
PHYSICAL SECTOR NUMBER:m+13
PHYSICAL SECTOR NUMBER:m+14
PHYSICAL SECTOR NUMBER:m+15
LOGICAL SECTOR NUMBER:m-1
LOGICAL SECTOR NUMBER:m
LOGICAL SECTOR NUMBER:m+1
LOGICAL SECTOR NUMBER:m+2
LOGICAL SECTOR NUMBER:m+3
LOGICAL SECTOR NUMBER:m+4
LOGICAL SECTOR NUMBER:m+12
LOGICAL SECTOR NUMBER:m+13
LOGICAL SECTOR NUMBER:m+14

FIG. 14

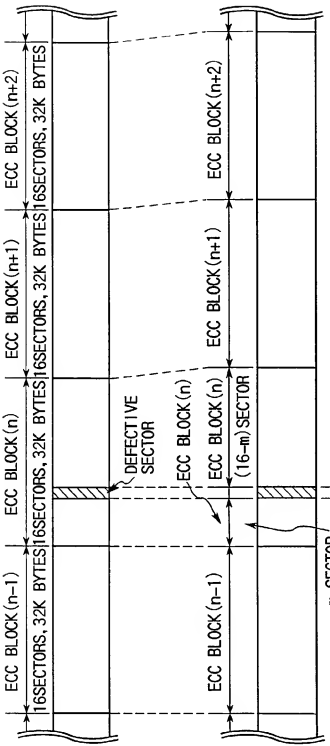
ECC BLOCK(n-1)
16SECTORS, 32K BYTES
ECC BLOCK(n)
16SECTORS, 32K BYTES
ECC BLOCK(n+1)
16SECTORS, 32K BYTES
ECC BLOCK(n+2)
16SECTORS, 32K BYTES
DEFECTIVE SECTOR
ECC BLOCK(n-1)
ECC BLOCK(n)
(16-m)SECTOR
ECC BLOCK(n+1)
ECC BLOCK(n+2)
m SECTOR
RECORDING INTERRUPTED
RECORDING RESUMPTION
INTERRUPTION PER100 (ONE SECTOR)

FIG. 15

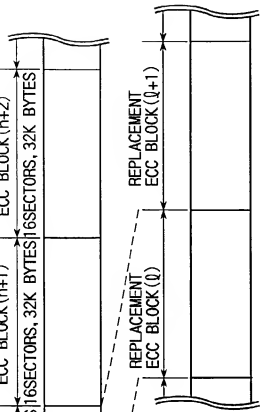
ECC BLOCK(n-1)
ECC BLOCK(n)
ECC BLOCK(n+1)
ECC BLOCK(n+2)
16SECTORS, 32K BYTES
16SECTORS, 32K BYTES
16SECTORS, 32K BYTES
16SECTORS, 32K BYTES
DEFECTIVE SECTOR
REPLACEMENT ECC BLOCK(Q)
REPLACEMENT ECC BLOCK(Q+1)

FIG. 16

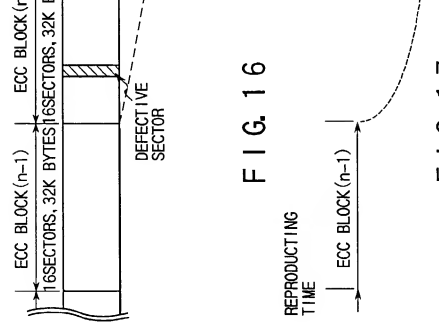
REPRODUCTING TIME
ECC BLOCK(n-1)
ECC BLOCK(n+1)
ECC BLOCK(n+2)
REPLACEMENT ECC BLOCK(Q)

FIG. 17

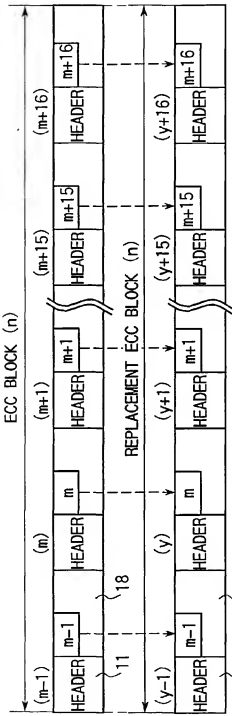
ECC BLOCK (n)
REPLACEMENT ECC BLOCK (n)
(m-1)
(m)
(m+1)
(m+15)
(m+16)
(y-1)
(y)
(y+1)
(y+15)
(y+16)
HEADER
m-1
m
m+1
m+15
m+16
11
18

FIG. 18

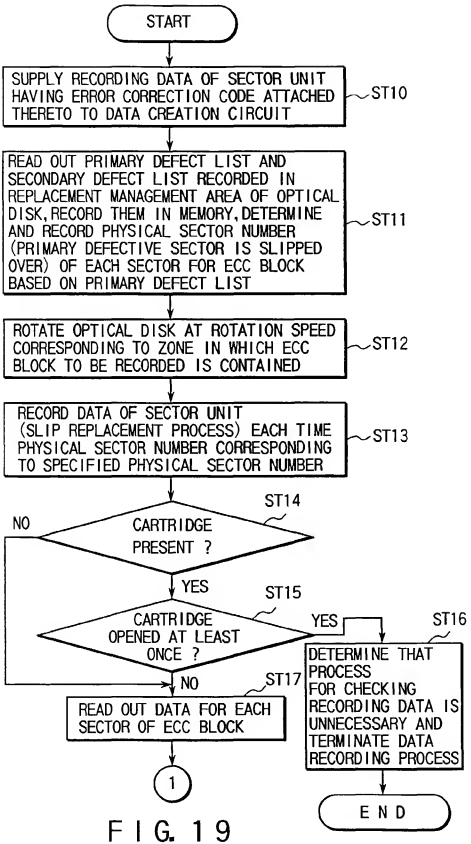
START
SUPPLY RECORDING DATA OF SECTOR UNIT HAVING ERROR CORRECTION CODE ATTACHED THERETO TO DATA CREATION CIRCUIT
ST10
READ OUT PRIMARY DEFECT LIST AND SECONDARY DEFECT LIST RECORDED IN REPLACEMENT MANAGEMENT AREA OF OPTICAL DISK, RECORD THEM IN MEMORY, DETERMINE AND RECORD PHYSICAL SECTOR NUMBER (PRIMARY DEFECTIVE SECTOR IS SLIPPED OVER) OF EACH SECTOR FOR ECC BLOCK BASED ON PRIMARY DEFECT LIST
ST11
ROTATE OPTICAL DISK AT ROTATION SPEED CORRESPONDING TO ZONE IN WHICH ECC BLOCK TO BE RECORDED IS CONTAINED
ST12
RECORD DATA OF SECTOR UNIT (SLIP REPLACEMENT PROCESS) EACH TIME PHYSICAL SECTOR NUMBER CORRESPONDING TO SPECIFIED PHYSICAL SECTOR NUMBER
ST13
ST14
CARTRIDGE PRESENT ?
NO
YES
ST15
CARTRIDGE OPENED AT LEAST ONCE ?
YES
ST16
DETERMINE THAT PROCESS FOR CHECKING RECORDING DATA IS UNNECESSARY AND TERMINATE DATA RECORDING PROCESS
NO
ST17
READ OUT DATA FOR EACH SECTOR OF ECC BLOCK
1
END

FIG. 19

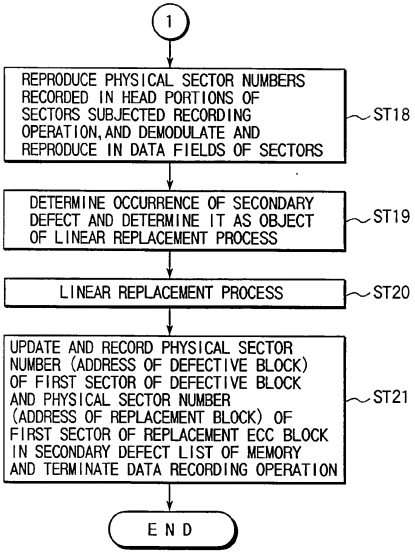
1
REPRODUCE PHYSICAL SECTOR NUMBERS RECORDED IN HEAD PORTIONS OF SECTORS SUBJECTED RECORDING OPERATION, AND DEMODULATE AND REPRODUCE IN DATA FIELDS OF SECTORS
ST18
DETERMINE OCCURRENCE OF SECONDARY DEFECT AND DETERMINE IT AS OBJECT OF LINEAR REPLACEMENT PROCESS
ST19
LINEAR REPLACEMENT PROCESS
ST20
UPDATE AND RECORD PHYSICAL SECTOR NUMBER (ADDRESS OF DEFECTIVE BLOCK) OF FIRST SECTOR OF DEFECTIVE BLOCK AND PHYSICAL SECTOR NUMBER (ADDRESS OF REPLACEMENT BLOCK) OF FIRST SECTOR OF REPLACEMENT ECC BLOCK IN SECONDARY DEFECT LIST OF MEMORY AND TERMINATE DATA RECORDING OPERATION
ST21
END

FIG. 20